

Highlights

World energy consumption is projected to increase by 71 percent from 2003 to 2030. Fossil fuels continue to supply much of the energy used worldwide, and oil remains the dominant energy source.

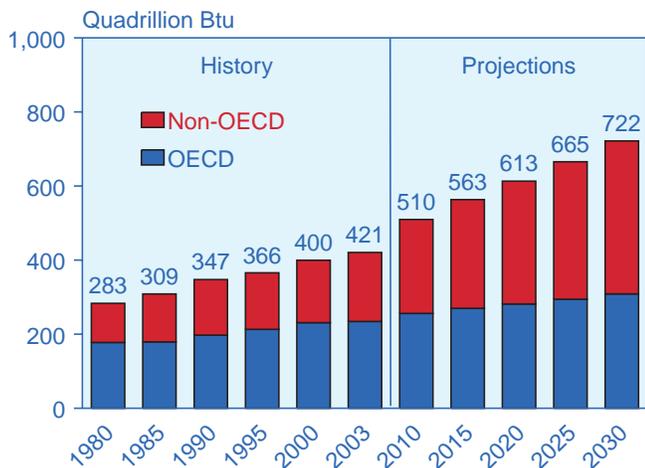
In the *International Energy Outlook 2006 (IEO2006)* reference case, world marketed energy consumption increases on average by 2.0 percent per year from 2003 to 2030. Although world oil prices in the reference case, which remain between \$47 and \$59 per barrel (in real 2004 dollars), dampen the growth in demand for oil, total world energy use continues to increase as a result of robust economic growth. Worldwide, total energy use grows from 421 quadrillion British thermal units (Btu) in 2003 to 563 quadrillion Btu in 2015 and 722 quadrillion Btu in 2030 (Figure 1).

The most rapid growth in energy demand from 2003 to 2030 is projected for nations outside the Organization for Economic Cooperation and Development (non-OECD nations). Energy demand growth averages 3.7 percent per year for non-OECD Asia (which includes China and India), 2.8 percent per year for Central and South America, 2.6 percent per year for Africa, 2.4 percent per year for the Middle East, and 1.8 percent per year for non-OECD Europe and Eurasia. The increases result from projections of strong regional economic growth. For all the non-OECD regions combined, economic activity—as measured by gross domestic product (GDP) in purchasing power parity terms—expands by 5.0 percent per year on average, as compared with an average of 2.6 percent per year for the OECD economies.

The OECD nations, for the most part, are more mature energy consumers with well-established infrastructures, and their economies generally are moving away from energy-intensive industries toward services. Consequently, total OECD energy demand increases by an average of 1.0 percent per year over the projection period, as compared with an average increase of 3.0 percent per year for total non-OECD energy demand.

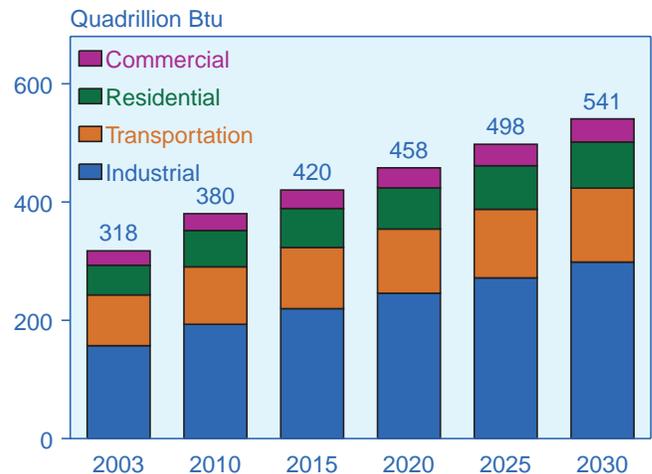
Trends in end-use sector energy consumption can vary widely, according to the level and pace of economic development in a given region. On a worldwide basis, energy demand in the industrial sector grows most rapidly, at an average rate of 2.4 percent per year (Figure 2). Slower growth is projected for the buildings sectors: residential energy use rises by an average of 1.7 percent per year and commercial energy use by 1.8 percent per year from 2003 to 2030 for the world as a whole. The slowest growth in energy demand among the end-use sectors is projected for transportation, at 1.4 percent per year. In contrast, the *International Energy Outlook 2005 (IEO-2005)* reference case showed transportation energy use growing at the same rate as industrial energy use and faster than energy use in the buildings sectors. The higher world oil prices in *IEO2006* are largely responsible for the slower growth in transportation sector energy

Figure 1. World Marketed Energy Consumption by Region, 1980-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2006).

Figure 2. World Delivered Energy Consumption by End-Use Sector, 2003-2030



Sources: **2003:** Derived from Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **2010-2030:** EIA, *System for the Analysis of Global Energy Markets* (2006).

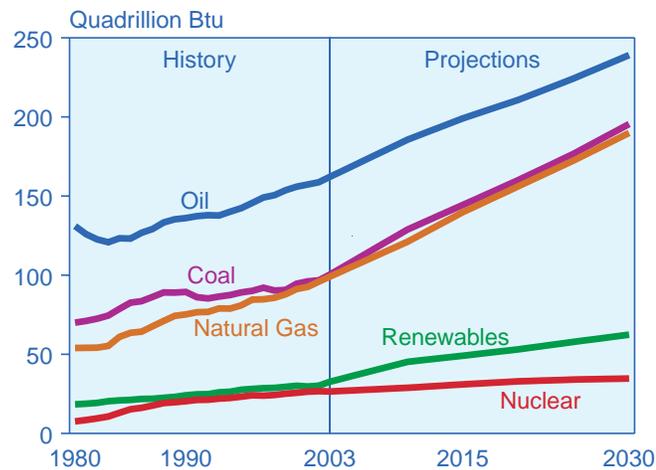
demand, in that oil dominates transportation energy use, and there are currently no fuels that compete widely with oil in the transportation sector.

In the OECD, where population growth generally is slow or negative in many countries over the projection period, the slowest growth in energy use is projected for the residential sector, at 0.6 percent per year; and the fastest growth is in the industrial sector, averaging 1.2 percent annually. For the non-OECD regions as a whole, strong growth in demand for energy is projected for every end-use sector, ranging from 2.3 percent per year in the transportation sector to 3.2 percent per year in the commercial and industrial sectors.

In the *IEO2006* reference case, the use of all energy sources increases through 2030 (Figure 3). Fossil fuels (oil, natural gas, and coal) continue to supply much of the energy used worldwide. Oil remains the dominant energy source, given its importance in the transportation and industrial end-use sectors; however, higher world oil prices in this year's outlook mean that oil's share of the world energy market is lessened in the projection as other fuels replace oil where possible. In *IEO2005*, in contrast, the oil share of total energy demand was relatively stable from 2002 to 2025. Renewable energy sources become more economically competitive with fossil fuels in the reference case, and renewable energy use expands as rapidly as consumption of natural gas and coal. Higher fossil fuel prices also support renewed interest in expanding the use of nuclear power to generate electricity.

World oil use grows from 80 million barrels per day in 2003 to 98 million barrels per day in 2015 and 118 million

Figure 3. World Marketed Energy Use by Energy Type, 1980-2030

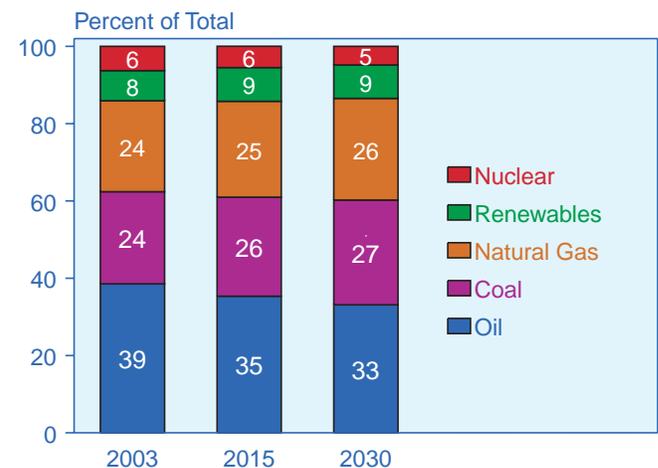


Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2006).

barrels per day in 2030 in the reference case. The *IEO2006* projection for oil demand in 2025 is 8 million barrels per day lower than the 119 million barrels per day projected in *IEO2005*, which extended only to 2025. The slower growth in this year's projections is in large part explained by the substantially higher world oil prices in the *IEO2006* reference case. Indeed, world oil prices in 2025—expressed as the average price of imported low-sulfur, light crude oil to U.S. refiners (see box on page 3)—are 35 percent higher than in *IEO2005*. In the *IEO2006* reference case, world oil prices rise from \$31 per barrel (in real 2004 dollars) in 2003 to \$57 per barrel in 2030, and oil's share of total world energy use falls from 39 percent to 33 percent (Figure 4).

To meet the projected increase in world oil demand in the reference case, total petroleum supply in 2030 will need to be 38 million barrels per day higher than the 2003 level of 80 million barrels per day. OPEC producers are expected to provide 14.6 million barrels per day of the increase. Higher oil prices cause a substantial increase in non-OPEC oil production—23.7 million barrels per day, which represents 62 percent of the increase in total world oil supplies over the projection period. In addition, unconventional resources (including biofuels, coal-to-liquids, and gas-to-liquids) are expected to become more competitive. In 2003, world production of unconventional resources totaled only 1.8 million barrels per day; in the *IEO2006* reference case, unconventional resource supplies rise to 11.5 million barrels per day and account for nearly 10 percent of total world petroleum supply in 2030.

Figure 4. Fuel Shares of World Marketed Energy Use, 2003, 2015, and 2030



Note: Fuel shares may not add to 100 percent due to independent rounding.

Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **2015 and 2030:** EIA, *System for the Analysis of Global Energy Markets* (2006).

The higher oil prices in this year's reference case raise the projected demand for, and price of, natural gas. Natural gas consumption increases on average by 2.4 percent per year from 2003 to 2030. The higher natural gas prices also make coal more cost-competitive, especially in the electric power sector. As a result, for the first time since the Energy Information Administration (EIA) began publishing outlooks for worldwide energy use in 1990, demand for coal grows faster than demand for natural gas in the *IEO2006* projections, albeit only slightly faster, at 2.5 percent per year. Among the end-use sectors, the industrial sector remains the largest consumer of natural gas worldwide, accounting for 52 percent of the total increase in demand for natural gas between 2003 and 2030. Natural gas also is expected to remain an important energy source in the electric power sector, particularly for new generating capacity.

World Oil Prices in *IEO2006*

In previous *IEOs*, the world crude oil price was defined on the basis of the average imported refiner acquisition cost of crude oil to the United States (IRAC), which represented the weighted average of all imported crude oil. Historically, the IRAC price has tended to be a few dollars less than the widely cited prices of premium crudes, such as West Texas Intermediate (WTI) and Brent, which refiners generally prefer for their low viscosity and sulfur content. In the past 2 years, the price difference between premium crudes and IRAC has widened—in particular, the price spread between premium crudes and heavier, high-sulfur crudes. In an effort to provide a crude oil price that is more consistent with those generally reported in the media, *IEO2006* uses the average price of imported low-sulfur, light crude oil to U.S. refiners.

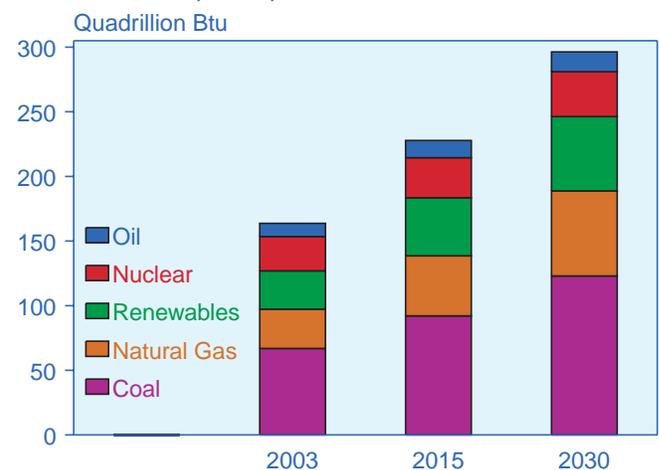
World coal consumption is projected to increase from 5,440 million short tons in 2003 to 7,792 million short tons in 2015, at an average annual rate of 3.0 percent. The rate of growth in world coal use slows after 2015 to 2.0 percent annually through 2030, when coal consumption totals 10,561 million short tons. Of the coal produced worldwide in 2003, 67 percent was shipped to electricity producers and 30 percent to industrial consumers, the two end-use sectors that account for virtually all the growth in coal use in the mid-term. On a worldwide basis coal's share of industrial sector energy use increases, mostly because of the substantial growth projected for coal consumption in China's industrial sector. In the *IEO2006* reference case, industrial energy use in China more than triples from 2003 to 2030 as a result of the country's abundant coal reserves, its limited reserves of oil and natural gas, and its leading position in world steel production.

World net electricity consumption more than doubles in the reference case, from 14,781 billion kilowatthours in 2003 to 21,699 billion kilowatthours in 2015 and 30,116 billion kilowatthours in 2030. Most of the growth in electricity demand occurs in the non-OECD nations, where electricity use increases on average by 3.9 percent per year from 2003 to 2030, as compared with 1.5 percent per year in the OECD nations. Worldwide, increases are projected for all primary energy sources in electricity generation (Figure 5). Coal and natural gas remain the most important fuels for electricity generation throughout the projection period, however, accounting for more than two-thirds of the total increment in energy use for electricity production in the reference case.

Consumption of electricity generated from nuclear power worldwide increases from 2,523 billion kilowatthours in 2003 to 3,299 billion kilowatthours in 2030 in the *IEO2006* reference case. Higher fossil fuel prices and concerns about security of energy supplies are expected to improve prospects for nuclear power capacity over the projection period, and many countries are expected to build new nuclear power plants. World nuclear capacity rises from 361 gigawatts in 2003 to 438 gigawatts in 2030, with significant declines in capacity projected only for Europe, where several countries have either plans or mandates to phase out nuclear power, or where old reactors are expected to be retired and not replaced.

Non-OECD Asia accounts for 69 percent of the increase in non-OECD nuclear capacity in the reference case and leads the growth in nuclear power generation with an average increase of 6.3 percent per year from 2003 to 2030

Figure 5. World Energy Consumption for Electricity Generation by Fuel Type, 2003, 2015, and 2030



Sources: **2003:** Derived from Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **2010-2030:** EIA, System for the Analysis of Global Energy Markets (2006).

2030. The 51 gigawatts of additional installed nuclear generating capacity projected for non-OECD Asia includes 33 gigawatts in China and 12 gigawatts in India. Russia accounts for most of the remaining non-OECD additions, adding 22 gigawatts of nuclear capacity over the 2003 to 2030 period.

Rising fossil fuel prices also allow renewable energy sources to compete economically in the electric power sector. Consumption of hydroelectricity and other grid-connected renewable energy sources expands by 2.4 percent per year—approximately the same as the rates of growth projected for natural gas and coal—and the renewable energy share of the world’s total energy consumption increases from 8 percent in 2003 to 9 percent in 2030.

Much of the projected growth in renewable electricity generation results from the expected completion of large hydroelectric facilities in non-OECD nations, especially in non-OECD Asia, where the need to expand electricity production with associated dams and reservoirs often outweighs concerns about environmental impacts and the relocation of populations. China, India, and Laos, among other non-OECD Asian economies, already are constructing or planning new large-scale hydroelectric facilities.

Apart from Turkey, where development of the 7.5-gigawatt Southeast Anatolia hydroelectric system is ongoing, most hydroelectric resources in the OECD nations already have been developed or lie far from population centers. As a result, nonhydroelectric marketed renewables, such as wind, solar, geothermal, and biomass, are expected to account for most of the growth in OECD renewable energy use, given government programs and policies to encourage their expansion.

World carbon dioxide emissions continue to increase steadily in the *IEO2006* reference case, from 25.0 billion metric tons in 2003 to 33.7 billion metric tons in 2015 and 43.7 billion metric tons in 2030. Carbon dioxide is one of the most prevalent greenhouse gases in the atmosphere, and anthropogenic (human-caused) emissions of carbon dioxide result primarily from the combustion of fossil fuels for energy. Three-fourths of the projected increase in carbon dioxide emissions results from fossil fuel consumption in non-OECD countries.

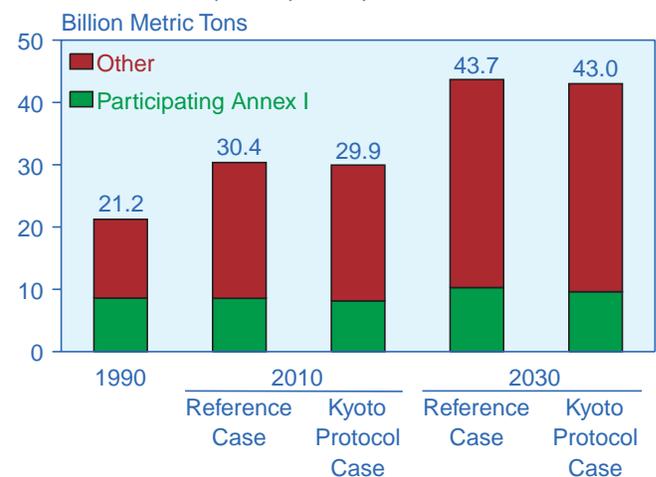
The Kyoto Protocol, which requires participating “Annex I” countries¹ to reduce their carbon dioxide emissions collectively to an annual average of about 5 percent below their 1990 level over the 2008-2012 period, became a legally binding treaty on February 16,

2006, 90 days after it was ratified by Russia. The *IEO2006* reference case does not include the potential impacts of the Kyoto Protocol, because the treaty does not indicate the methods by which ratifying parties will implement their obligations either in the first commitment period or after 2012. To examine the implications of the treaty for energy use and carbon dioxide emissions, a Kyoto Protocol case was analyzed.

A number of assumptions were made in developing the *IEO2006* Kyoto Protocol case. First, it was assumed that energy use would not vary from the reference case projection for countries that are not undertaking emissions reduction commitments. In addition, assumptions were made about how the affected participating regions would achieve their reductions. In OECD Europe, stated intentions that “most” of the emissions reductions will be achieved domestically led to an assumption that 50 percent of the aggregate emissions reduction for OECD Europe would be met by domestic reductions. With no stated intentions about levels of domestic reductions in Japan or in Canada, an assumption was made that a 25-percent share of total reductions in both countries would be met domestically. Finally, it was assumed that the emissions commitments would remain in effect at their 2008-2012 level through 2030.

In the Kyoto Protocol case (Figure 6), energy-related carbon dioxide emissions in the participating nations are 673 million metric tons lower than in the reference case

Figure 6. World Carbon Dioxide Emissions in Two Cases, 1990, 2010, and 2030



Sources: **1990:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **2010 and 2030:** EIA, *System for the Analysis of Global Energy Markets* (2006).

¹Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom. Australia, Belarus, Turkey, and the United States are Annex I nations that will not participate in the Protocol.

in 2030. In those countries required to make reductions in the Kyoto Protocol case (Canada, Japan, and OECD Europe), emissions decline from 6.1 billion metric tons in 2003 to 5.9 billion metric tons in 2010. After 2010, however, their emissions begin to rise again—to 6.5 billion metric tons in 2030—when participants find it less expensive to purchase permits than to make domestic reductions.

Continued heavy reliance on coal and other fossil fuels in many parts of the world suggests that even if nations that have ratified the Kyoto Protocol reduce their carbon dioxide emissions as required in the treaty, there still will be substantial increases in carbon dioxide emissions worldwide. In the *IEO2006* Kyoto Protocol case, worldwide carbon dioxide emissions rise to 29.9 billion metric tons in 2010 and 43.0 billion metric tons in 2030.

